

This listing of claims will replace all prior versions, and listing of claims in the application:

Listing of Claims:

What is claimed is:

1. (Original) A CVI/CVD process, comprising the steps of:
partially densifying a porous structure within a CVI/CVD furnace by depositing a first matrix within said porous structure with a pressure gradient CVI/CVD process in which a first portion of said porous structure is subjected to a greater pressure than a second portion of said porous structure and said first portion has a greater bulk density gain than said second portion; and,
subsequently densifying said porous structure by depositing a second matrix within said porous structure with at least one additional densification process in which said second portion has a greater bulk density gain than said first portion.
2. (Original) The process of claim 1, wherein said additional densification process is a conventional CVI/CVD process.
3. (Original) The process of claim 1, wherein said additional densification process is a pressure gradient CVI/CVD process in which said second portion is subjected to a higher pressure than said first portion.
4. (Original) The process of claim 1, wherein said additional densification process is a resin impregnation process, and further comprising the step of charring said resin.
5. (Original) The process of claim 1, further comprising the step of heat treating said partially densified porous structure at a temperature greater than said pressure gradient CVI/CVD process before said step of subsequently densifying the porous structure by at least one additional densification process.

6. (Original) The process of claim 1, wherein said porous structure is a carbon porous structure and said pressure gradient CVI/CVD process deposits a carbon matrix within said porous structure.

7. (Original) The process of claim 1, wherein said porous structure is annular and has two generally planar opposing surfaces, and said first portion includes one of said two opposing surfaces, and said second portion includes the other of said two opposing surfaces.

8. (Original) The process of claim 1, wherein said porous structure is annular and has an inside circumferential surface and an outside circumferential surface, and said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

9. (Original) The process of claim 1, wherein said porous structure is annular and has an inside circumferential surface and an outside circumferential surface, and said first portion includes said outside circumferential surface, and said second portion includes said inside circumferential surface.

10. (Original) The process of claim 1, wherein said porous structure is annular and has an inside circumferential surface and an outside circumferential surface, and said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

11. (Original) The process of claim 1, wherein said porous structure is annular and has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said inside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said outside circumferential surface and the other of said two generally parallel planar surfaces.

12. (Original) The process of claim 1, wherein said porous structure is annular and has two generally parallel planar surfaces bounded by an inside circumferential surface

and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said outside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said inside circumferential surface and the other of said two generally parallel planar surfaces.

13. (Original) The process of claim 1, further comprising the step of heat treating said porous structure at a temperature greater than said pressure gradient CVI/CVD process after said pressure gradient CVI/CVD process and before said step of subsequently densifying said porous structure.

14. (Original) The process of claim 1, wherein said step of heat treating said porous structure follows said pressure gradient CVI/CVD process without removing said porous structure from said CVI/CVD furnace.

15. (Original) A CVI/CVD process, comprising the steps of:
partially densifying a multitude of annular fibrous carbon structures within a CVI/CVD furnace by depositing a first carbon matrix within said annular fibrous carbon structure with a pressure gradient CVI/CVD process in which a first portion of each annular fibrous carbon structure is subjected to a higher pressure than a second portion of each annular fibrous carbon structure and said first portion has a greater bulk density gain than said second portion; and,

subsequently densifying said multitude of annular fibrous carbon structures by depositing a second carbonaceous matrix within each annular fibrous carbon structure with at least one additional densification process in which said second portion has a greater bulk density gain than said first portion.

16. (Original) The process of claim 15, wherein each annular fibrous carbon structure has two generally parallel planar surfaces, and said first portion includes one of said two generally parallel planar surfaces, and said second portion includes the other of said two generally parallel planar surfaces.

17. (Original) The process of claim 15, wherein each annular fibrous carbon structure has an inside circumferential surface and an outside circumferential surface, said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

18. (Original) The process of claim 15, wherein each annular fibrous carbon structure has an inside circumferential surface and an outside circumferential surface, and said first portion includes said outside circumferential surface, and said second portion includes said inside circumferential surface.

19. (Original) The process of claim 15, wherein each annular fibrous carbon structure has an inside circumferential surface and an outside circumferential surface, and said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

20. (Original) The process of claim 15, wherein each annular fibrous carbon structure has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said inside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said outside circumferential surface and the other of said two generally parallel planar surfaces.

21. (Original) The process of claim 15, wherein each annular fibrous carbon structure has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said outside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said inside circumferential surface and the other of said two generally parallel planar surfaces.

22. (Original) The process of claim 15, further comprising the step of heat treating said annular fibrous carbon structure at a temperature greater than said pressure

gradient CVI/CVD process after said pressure gradient CVI/CVD process and before said step of subsequently densifying said annular fibrous carbon structure.

23. (Original) The process of claim 22, wherein said step of heat treating said porous structure follows said pressure gradient CVI/CVD process without removing said porous structure from said CVI/CVD furnace.

24. (Original) A CVI/CVD process, comprising the steps of:
heating a porous carbon structure to a temperature of at least 1750 °F;
heating a hydrocarbon reactant gas to a temperature of at least 1650 °F;
partially densifying said porous carbon structure by forcing said reactant gas to pass through said porous carbon structure from a first portion of said fibrous structure to a second portion of said porous carbon structure, said first portion having a greater bulk density gain than said second portion; and,
subsequently densifying said porous carbon structure by depositing a second matrix within said porous carbon structure with at least one additional densification process in which said second portion has a greater bulk density gain than said first portion.

25. (Original) The process of claim 24, wherein said second matrix is a carbon matrix and said additional densification process is a conventional CVI/CVD process.

26. (Original) The process of claim 24, wherein said additional densification process comprises the steps of:
heating a porous carbon structure to a temperature of at least 1750 °F;
heating a hydrocarbon reactant gas to a temperature of at least 1650 °F; and,
passing said reactant gas around said porous structure.

27. (Original) The process of claim 24, further comprising the step of heat treating said porous carbon structure at a temperature of at least 3300 °F after said step of partially densifying said porous carbon structure and before said step of subsequently densifying said porous carbon structure.

28. (Original) The process of claim 27, wherein said step of heat treating said porous structure follows said pressure gradient CVI/CVD process without removing said porous carbon structure from said CVI/CVD furnace.

Claims 29-52 (cancelled).

53. (Original) A CVI/CVD process in a CVI/CVD furnace, comprising the steps of:

introducing a reactant gas into a sealed preheater disposed within said CVI/CVD furnace, said sealed preheater having a preheater inlet and a preheater outlet, said reactant gas being introduced into said preheater inlet and exiting said sealed preheater through said preheater outlet and infiltrating at least one porous structure disposed within said CVI/CVD furnace;

heating said at least one porous structure;

heating said sealed preheater to a preheater temperature greater than said reactant gas temperature;

sensing a gas temperature of said reactant gas proximate said outlet;

adjusting said preheater temperature to achieve a desired gas temperature; and, exhausting said reactant gas from said CVI/CVD furnace.

54. (Original) The process of claim 53, wherein said CVI/CVD furnace comprises a susceptor wall, and further comprising the step of heating said susceptor wall, and said step of heating said sealed preheater comprises the step of radiating heat energy from said susceptor wall to said sealed preheater.

55. (Original) The process of claim 53, wherein said sealed preheater is disposed in close proximity to said susceptor wall.

56. (Original) The process of claim 53, wherein said CVI/CVD furnace comprises a susceptor wall having at least first and second susceptor wall portions and at least first and second induction coils, said first induction coil being inductively coupled to said first susceptor wall in a manner that transforms electrical energy from said first

induction coil to heat energy in said first susceptor wall, and said second induction coil being inductively coupled to said second susceptor wall portion in a manner that transforms electrical energy from said second induction coil to heat energy in said second susceptor wall portion, said sealed preheater being disposed proximate said first susceptor wall portion and being heated to said preheater temperature at least in part by radiant heat energy from said first susceptor wall portion; and

wherein said step of adjusting said heat exchanger temperature comprises the step of adjusting electrical power to said first induction coil.

57. (Original) The process of claim 53, wherein said CVI/CVD furnace comprises a cylindrical susceptor wall having at least first and second cylindrical susceptor wall portions and at least first and second cylindrical induction coils, said first cylindrical induction coil being concentrically disposed around and inductively coupled to said first cylindrical susceptor wall in a manner that transforms electrical energy from said first cylindrical induction coil to heat energy in said first cylindrical susceptor wall, and said second cylindrical induction coil being concentrically disposed around and inductively coupled to said second cylindrical susceptor wall portion in a manner that transforms electrical energy from said second cylindrical induction coil to heat energy in said second cylindrical susceptor wall portion, said sealed preheater defines a generally cylindrical preheater perimeter concentrically disposed within and in close proximity to said first cylindrical susceptor wall portion and being heated to said preheater temperature at least in part by radiant heat energy from said first cylindrical susceptor wall portion; and

wherein said step of adjusting said preheater temperature comprises the step of adjusting electrical power to said first induction coil.

58. (Original) The process of claim 53, wherein said CVI/CVD furnace comprises a generally cylindrical susceptor wall, and said sealed preheater comprises a generally arcuate preheater perimeter in close proximity to said cylindrical susceptor wall.

59. (Original) The process of claim 53, wherein said sealed preheater is resistance heated by electrical energy.

60. (Original) The process of claim 53, wherein said preheater outlet comprises an array of perforations.

61. (Original) The process of claim 53, wherein said at least one porous structure comprises a first portion and a second portion; and,
further comprising the step of forcing said reactant gas to pass through said at least one porous structure from said first portion to said second portion.

62. (Original) The process of claim 61, wherein said reactant gas deposits a carbon matrix having a substantially rough laminar microstructure within said at least one porous structure.

63. (Original) The process of claim 53, wherein said at least one porous structure is a carbon porous structure, and said reactant gas deposits a carbon matrix within said at least one porous structure.

64. (Original) The process of claim 53, wherein said at least one porous structure comprises a plurality of annular porous structures disposed in a stack that defines an annular porous wall; and,
further comprising the step of forcing dispersion of said reactant gas through said annular porous wall by introducing said reactant gas to said CVI/CVD furnace and exhausting said reactant gas from said CVI/CVD furnace on opposite sides of said annular porous wall.

65. (Original) The process of claim 64, wherein each annular porous structure has a surface area, said stack of annular porous structures having at least one ring concentrically disposed between each pair of adjacent porous structures with a majority of said surface area of each annular porous structure being exposed to said reactant gas.

66. (Original) The process of 64, wherein said stack defines an enclosed cavity bounded by said annular porous wall; and,
further comprising the step of introducing said reactant gas from said preheater outlet into said enclosed cavity, said enclosed cavity being sealed to said preheater outlet.

67. (Original) A CVI/CVD process in a CVI/CVD furnace, comprising the steps of:

forming an annular porous wall that defines an enclosed cavity, said porous annular wall including a stack of annular fibrous carbon structures;

sealing said annular porous wall to a sealed preheater, said sealed preheater having a preheater inlet and a preheater outlet, said enclosed cavity being in fluid communication with said gas outlet;

introducing a carbon bearing reactant gas into said preheater inlet, directing said gas through said sealed preheater, to said preheater outlet, and into said enclosed cavity;

heating said annular porous wall;

heating said preheater to a preheater temperature greater than a gas temperature of said reactant gas proximate said preheater inlet;

sensing a gas temperature of said reactant gas proximate said preheater outlet;

adjusting said preheater temperature to achieve a desired gas temperature; and,

withdrawing said reactant gas from said CVI/CVD furnace on a side of said annular porous wall opposite said enclosed cavity thereby forcing dispersion of said reactant gas introduced into said enclosed cavity through said annular porous wall.

68. (Original) The process of claim 67, wherein said CVI/CVD furnace comprises a susceptor wall having at least first and second susceptor wall portions and at least first and second induction coils, said first induction coil being inductively coupled to said first susceptor wall in a manner that transforms electrical energy from said first induction coil to heat energy in said first susceptor wall, and said second induction coil being inductively coupled to said second susceptor wall portion in a manner that transforms electrical energy from said second induction coil to heat energy in said second susceptor wall portion, said preheater being disposed proximate said first susceptor wall portion and being heated to said preheater temperature at least in part by radiant heat energy from said first susceptor wall portion; and

wherein said step of adjusting said preheater temperature comprises the step of adjusting electrical power to said first induction coil.

69. (Original) The process of claim 67, wherein said reactant gas deposits a carbon matrix having a substantially rough laminar microstructure within said annular porous wall.

70. (Original) The process of claim 67, wherein each annular fibrous carbon structure has a surface area, said stack having at least one ring concentrically disposed between each pair of adjacent annular fibrous carbon structures with a majority of said surface area of each annular fibrous carbon structure being exposed to said reactant gas.

Claims 71-83 (cancelled).

84. (Original) A CVI/CVD densification process, comprising the steps of:
densifying a first porous wall within a CVI/CVD furnace by a pressure gradient CVI/CVD process wherein a first flow of reactant gas is forced to disperse through said first porous wall;

densifying a second porous wall by a pressure gradient CVI/CVD process wherein a second flow of reactant gas is forced to disperse through said second porous wall;
and,

independently controlling said first flow of said reactant gas and said second flow of said reactant gas.

85. (Original) The process of claim 84, further comprising the steps of:
densifying at least a third porous wall by a pressure gradient CVI/CVD process wherein at least a third flow of reactant gas is forced to disperse through at least said third porous wall; and

independently controlling at least said third flow of reactant gas.

86. (Original) The process of claim 84, further comprising the steps of:
sensing a first porous wall temperature; and,
controlling said first porous wall temperature by increasing or decreasing said first flow of reactant gas.

87. (Original) The process of claim 86, further comprising the steps of:

sensing a second porous wall temperature; and,
controlling said second porous wall temperature by increasing or decreasing
said second flow of reactant gas.

88. (Original) The process of claim 84, wherein:

said step of densifying said first porous wall includes the step of subjecting
one side of said first porous wall to said first flow of reactant gas at a first pressure and an
opposing side of said first porous wall to a vacuum pressure, said first pressure being greater
than said vacuum pressure; and,

said step of densifying said second porous wall includes the step of subjecting
one side of said second porous wall to said second flow of reactant gas at a second pressure
and an opposing side of said second porous wall to a vacuum pressure, said second pressure
being greater than said vacuum pressure

89. (Original) The process of claim 88, further comprising the steps of:

sensing said first pressure; and,
controlling said first pressure by increasing or decreasing said first flow of
reactant gas.

90. (Original) The process of claim 89, further comprising the steps of:

sensing said second pressure; and,
controlling said second pressure by increasing or decreasing said second flow
of reactant gas.